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NEW YORK, N. Y.

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SENILE ATROPHY OF THE UPPER JAW.

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With advancing age the human organism is reduced in size and weight; the more so, as a rule, after the "threescore years and ten" have passed. The whole body shrinks, as well as all its individual tissues. Age itself is disease. The old Roman proverb says, "And the aged returns to childhood, both mentally and physically." The questions which we have tried to solve are, In what does this atrophy take place? What are its visible signs under the microscope?

Through the kindness of Dr. Emmons Paine, superintendent of the insane hospital in Westborough, Mass., we came into possession of the upper jaw of a woman, who died at the age of seventy-five years. The jaw, immediately after removal, was placed in a one-half of one per cent. solution of chromic acid, in which it remained for several weeks, for the purpose of softening the bony parts. We lay stress upon this fact, since previous researches upon senile bone have been made upon dried specimens, by which method we are convinced that the results of microscopical research must have been marred, if not rendered futile. The whole thickness of this jaw, from the oral to the nasal surface, was not more than from four to five millimeters; the oral surface was perfectly smooth, without a trace of a tooth or a socket. A slight indication of the central raphe could be seen. Vertical sections through it give striking pictures of far-advanced senile atrophy. (See Fig. 1.)

The stratified epithelium of the oral mucosa terminates in an almost even line without the least indications of previous gums, the sum total of the epithelium being considerably narrowed. The papillæ, so prominent in the region of the gums in a normal condition, are still present, but considerably shortened and narrowed. The fibrous connective tissue is markedly reduced in its total quantity, as well as in the width of its bundles, as seen best in their transverse section. The connective tissue, including that of the previous gums and that of the periosteum, runs in an almost horizontal course, being interlaced by

bundles and tracts at an almost rectangular direction. It is traversed by numerous fissures, or slits, which were probably caused by mechanical injury in the process of cutting. This feature in otherwise perfect sections would indicate that the connection of the bundles is an extremely delicate one. Fat-tissue, so abundant both in the periosteal

FIG. 1.

ATROPHIED UPPER JAW. VERTICAL SECTION.—*E*, stratified epithelia of mucosa of oral cavity; *L*, longitudinal bundles of fibrous connective tissue; *T*, transverse bundles of fibrous connective tissue; *S*, spaces in connective tissue; *F*, fat-globules; *C*, hyaline cartilage; *A*, artery, probably in a previous alveolar canal; *B*, cancellous bone; *M*, Medullary space. × 50.

connective tissue and the medullary spaces of the cancellous bone of the jaws of the young and middle-aged, is extremely scanty. The bone itself produces only thin ledges bordered by an irregularly corroded line, without a distinction between compact and cancellous structure. The medullary spaces are greatly varying in size, and

filled either with a delicate fibrous connective tissue, or with granular matter, probably disintegrated protoplasm. The most striking feature is the presence of portions of hyaline cartilage, at the same height with the bony tissues left, which goes far to prove that the cartilage has grown from a previous bony structure, and in a measure is replacing it. As is well known, hyaline cartilage is present in the lower jaw only at the earliest stages of embryonal life, up to the eighth week of development. Around and from this so-called primordial cartilage bone-tissue develops, and in the third month of intra-uterine life all vestige of cartilage is lost. How much hyaline cartilage has to do with the development of the upper jaw, we are unable to tell. Most anatomists consider the upper jaw as having sprung from fibrous connective tissue, in a way similar to that of all flat facial and skull bones. However this may be, it is certainly remarkable that hyaline cartilage should reappear in the upper jaw of the aged, proving, as it were, that advanced age is a recurrence of childhood, even to intra-uterine life.

Let us now consider the senile changes of the tissues involved in the formation of the upper jaw.

1. *Epithelium.*—As mentioned before, the layer of stratified epithelium has been considerably reduced in bulk, although its three constituent portions are still recognizable, the main mass being made up of cuboidal epithelia, whereas the outermost or horny layer is composed of several rows of flat epithelia, and the border toward the connective tissue is established by a single row of columnar epithelium. (See Fig. 2.)

Horizontal sections through the mucosa show the thinning of the epithelial layer even better than vertical ones ; in the former, also, the row of columnar epithelia is better marked than in vertical sections. Most of the epithelia are much less conspicuous than in childhood or middle age. This may be accounted for, first, by the fine granulation of both the protoplasm and the nuclei ; secondly, by a reduction in the amount of the intervening cement-substance ; and thirdly, by a noticeable reduction of the bulk of each epithelium. An additional feature is that many of the original epithelia seem to have split up into smaller lumps. In many instances, only faintly-outlined nuclei are to be seen, so closely packed together that but little intervening protoplasm is discernible.

In many cases cement-substance is lacking altogether, to such an extent that the impression of multinuclear bodies is produced ; wherever cement-substance is present, though its ledges be ever so narrow, the delicate thorns traversing it are invariably traceable.

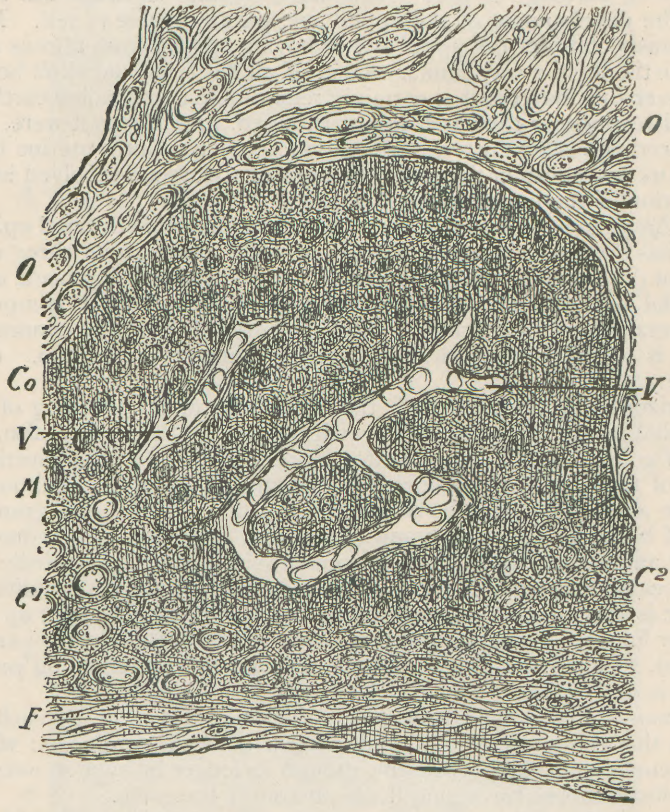
In some places, however, the nuclei of the cuboidal epithelia are almost solid glistening lumps, such as we are accustomed to see in either a juvenile or an inflamed condition of epithelium.

Broader epithelial valleys show in vertical sections narrow crevices, each holding a minute capillary blood-vessel. This may be explained by the shrinkage of previous papillæ ; though this view is hardly tenable in the face of the fact that all well-pronounced papillæ are supplied with a small number of blood-vessels. The view is more probable that capillaries with a little accompanying connective tissue have grown into the epithelial layer from without, thus causing, or at least assisting in, the atrophy of the epithelium.

This much is certain, that the reduction of the sum-total of the

covering epithelium is caused mainly by a reduction in the size of each epithelial body. We are, however, unable to say where the lost material has gone, unless it was absorbed by newly-formed capillaries grown into the epithelial layer. A transformation of the epithelia, first into medullary corpuscles, and afterward into connective tissue, a process so common in inflammation and the formation of tumors, could nowhere be satisfactorily proven in our specimens, and seems to be

FIG. 2.



ORAL EPITHELIUM OF SENILE UPPER JAW. VERTICAL SECTION.—*F*, layer of flat epithelia: C^1, cuboidal epithelia with solid nuclei; C^2, cuboidal epithelia of small size, with small vesicular nuclei; *M*, multinuclear layers of protoplasm; *Co*, columnar epithelium; *V*, *V*, capillary blood-vessels traversing the middle epithelial layer; *O*, *O*, myxofibrous connective tissue of oral mucosa. $\times$ 600.

little probable, since, as stated above, the columnar epithelia appear unbroken; possibly mastication has been more or less instrumental in removing layer after layer of epithelia.

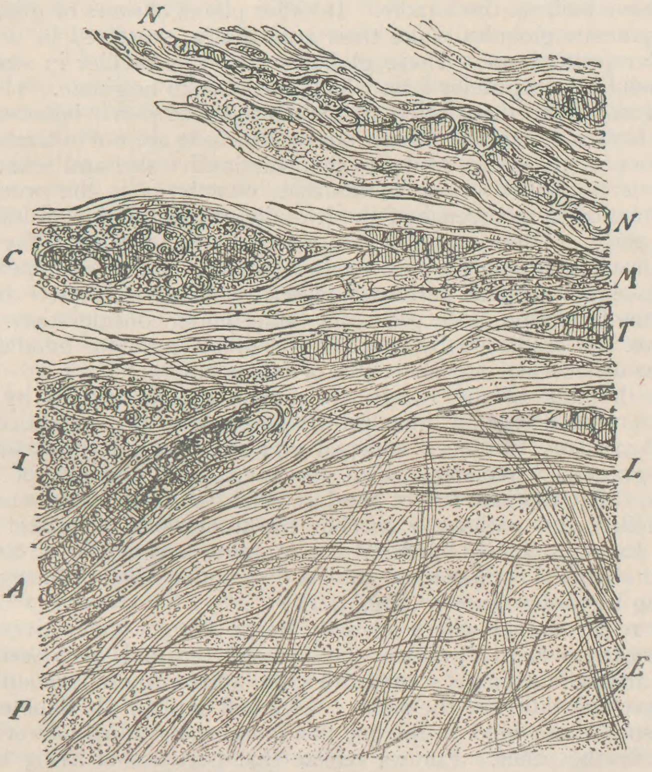
2. *Fibrous Connective Tissue.*—The senile changes of the oral mucosa are explicable only upon the fact, established by one of us in 1873, that the protoplasmic bodies lie between the bundles of the fibrous connective tissue, and the bundles themselves are not alto-

gether inert glue-yielding basis-substance, but are traversed by an extremely delicate, almost rectangular, net-work of living matter. The bundles, therefore, are possessed of life as well as protoplasm itself.

Close around the epithelia, and in the remnants of the papillæ, we notice delicate bundles holding a large number of finely granular bodies, and but a small number of capillary blood-vessels.

This tissue certainly differs from what we are accustomed to see in youth and in middle age. It may be termed myxofibrous connective

FIG. 3.



ORAL MUCOSA OF SENILE UPPER JAW. HORIZONTAL SECTION.—*L*, longitudinal bundles of fibrous connective tissue ; *T*, transverse bundles of fibrous connective tissue ; *N*, *N*, medullated nerve-fiber ; *A*, artery ; *C*, capillary blood-vessel partly narrowed, partly obliterated ; *M*, bundle of fibrous connective tissue split up into medullary corpuscles ; *I*, cluster of indifferent corpuscles ; *E*, elastic fiber ; *P*, finely granular protoplasm. × 600.

tissue, such as is seen in tumors of the skin and mucous layers, termed myxofibromata. This tissue exhibits the same aspect, both in vertical and horizontal sections of the senile jaw. (See Fig. 2, *O*, *O*.)

The fibrous tissue proper is, as above mentioned, noticeable by the small size of its constituent bundles, as shown both in their longitudinal and transverse sections. The changes of this tissue and its tenants, which are obviously the result of advanced age, are really surprising. (See Fig. 3.)

The bundles quite frequently show, under lower powers of the microscope, a faint granulation, which, if viewed with high powers, proves to be the reticulum of living matter already alluded to. This goes to prove that the tissues, especially their matrices, or basis-substances, remain alive to the last. Some of the longitudinal bundles appear split up into faintly-marked medullary corpuscles, especially in their longitudinal sections (Fig. 3, *M*). Here, evidently, a slight liquefaction of the glue-yielding basis-substance has occurred, leading, as it were, to a rejuvenescence of the bundle, *i.e.*, a reappearance of those embryonal corpuscles which in the earliest stage of development have built up the bundle. In other places clusters of glistening homogeneous globules make their appearance, scattered in a finely granular protoplasm. These globules are even smaller in size than the medullary corpuscles from which ameloblasts originate. (Fig. 3, *I.*) Nests of this description are similar to those seen in inflammation of the fibrous connective tissue, but we conclude are not inflammatory nests in our specimens, owing to their diminutive size and scantiness. There is no doubt in our minds that, exactly as in the process of inflammation, a recurrence of the juvenile or medullary condition has taken place. There is no doubt either that a liquefaction of the basis-substance has taken place in these nests, leading first to a reappearance of protoplasm, and afterward to an increase of the living matter thereof, up to the formation of the glistening lumps under consideration. The nests are still traversed by faint vestiges of the previous bundles, the same as we observe in early stages of inflammation.

The thinning of the bundles is unquestionably caused by their gradual transformation into protoplasm, since the interstices are found, in many instances, widened and filled with protoplasm of a finely granular character, which means a small amount of living matter. The ultimate fate of the bundles is, that the basis-substance is liquefied, and nothing is left but the framework of elastic fibers which have previously bordered the bundles, and which, on account of their chemical composition, are less destructible than ordinary glue-yielding basis-substance. (Fig. 3, *E.*)

The result is that where formerly dense fibrous connective tissue was present a faintly granular protoplasmic mass is now seen, the living matter of which is scanty and pale, apparently on account of a hydropic infiltration of the same. This will explain the flabbiness of the tissues of the aged on the one hand, and the gradual loss of living matter on the other. For we realize that particles of living matter with serum imbibed will be gradually detached from the mother soil, disintegrated, and taken back into the circulation through the scanty blood- and lymph-vessels left. The general shrinkage of the body thus becomes intelligible.

3. *Blood-Vessels.*—The fibrous connective tissue of the oral mucosa is, as is well known, freely supplied with blood-vessels—arteries, capillaries, and veins—during the ascending period of life, while it holds surprisingly few vessels in advanced age. In our specimens we have a good opportunity to trace the manner in which the blood-vessels perish. Smaller arteries show in their muscular walls an augmentation of the nuclei to such an extent that the spindles of the smooth muscle-fibers become replaced by rows of minute glistening globules (Fig. 3, *A*). An artery may thus become so changed in

its aspect that it were impossible to tell its original character, except through its attachment to a less altered artery of which it forms a branch. The endothelium of the inner coat likewise is enlarged and more or less crowded with coarse granules of living matter, by which means the caliber becomes at first narrowed and ultimately choked. The fibrous connective tissue of the adventitial coat behaves in a way similar to that of the mucosa generally, *i.e.*, it is gradually reduced to its juvenile or embryonal condition. After an artery has thus become impermeable to the current of the blood, it is in turn transformed into a solid tract of fibrous connective tissue, and as such is subject to the changes above described. The capillaries being composed of a single endothelial wall only, are easily traceable in their course to final obliteration. The endothelia swell up, become coarsely granular, and, by their bulging, the caliber is narrowed and rendered star-shaped. The augmentation of the living matter proceeds up to a complete occlusion of the caliber, such as is often seen in the process of inflammation. The result is a solid cluster of protoplasm in place of the previously hollow vessel. It seems that the nests of the glistening globules above alluded to are mostly present in the neighborhood of blood-vessels, or in places where blood-vessels had previously been. (Fig. 3, *C.*) Those who favor the emigration theory in inflammation must be at a loss to explain the appearance of indifferent or inflammatory corpuscles in places where the blood-vessels have perished. With us who urge the origin of such corpuscles both from the protoplasm—respectively its living matter and the living matter of the basis-substance—the images furnished by the microscope are explicable without any difficulty. That veins are gradually being obliterated in a way similar to that of arteries and capillaries is almost a matter of course, although we have not been able to trace this process directly in our specimens.

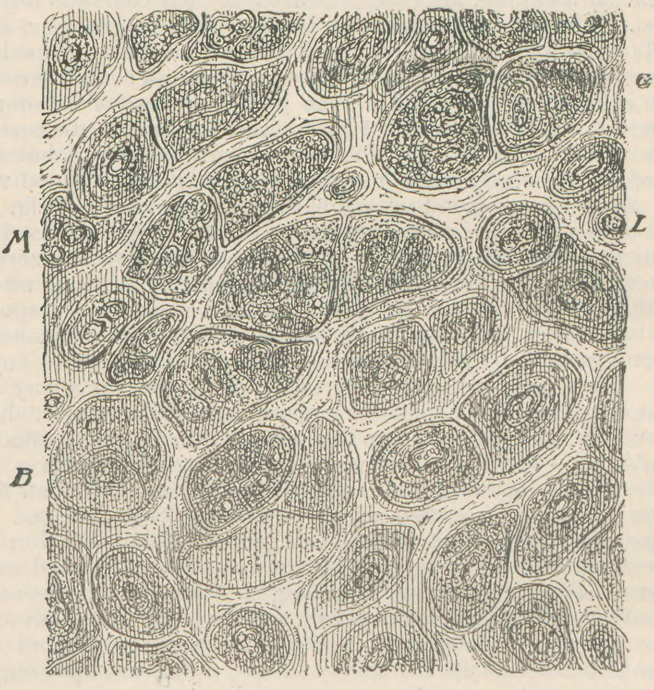
4. *Nerves.*—Here and there we meet with medullated nerves, recognizable as such by their course and their connection with other little or entirely unchanged nerves, which exhibit striking changes. Such changes are usually met with in the process of neuritis ; but in this instance, neuritis not being present, they must be attributed to senile changes. There is nothing surprising in the similarity between inflammation and senile metamorphosis, since both are essentially a return to the juvenile or medullary condition. Some medullated nerves appear to be broken up into glossy lumps, owing to a splitting up of the myelin ; at the same time the parallelism of the contours is lost, and the nerves show spindle-shaped widenings, alternating with narrow tracts. (Fig. 3, *N, N.*) The shining lumps are, probably at least, transformed into protoplasmic or medullary bodies, which in turn are transformed into spindles, and ultimately into fibrous connective tissue. Thus both the constrictions in the course of the nerve and the augmentation of the perineurium become intelligible, as well as the final loss of nerves, through their transformation into fibrous connective tissue. As to the changes of the axis-cylinders, we have nothing to say, since medullated nerves are unfit for the study of this particular portion.

5. *Cartilage.*—The appearance of hyaline cartilage (Fig. 4) in a senile jaw is, as we have before remarked, a most surprising fact, going far to prove that rejuvenescence of the tissues takes place in old age. Hyaline cartilage is, no doubt, a transient or provisional tissue in

early embryonal life, and the same seems to be the case in declining age, since it appears as a mere intermediate tissue between previous bone and the ultimate tissue, *i.e.*, fibrous connective tissue.

Hyaline cartilage in this case appears as a thin rounded-off plate, characterized by small and flat cartilage-corpuscles along the borders, whereas the central portions are made up of comparatively large and coarse granular bodies, if viewed with lower powers of the microscope. The borders of this tissue are intimately connected with fibrous connective tissue. (See Fig. 1, *C.*)

FIG. 4.



CARTILAGE FROM SENILE JAW.—*M*, medullary corpuscles; *L*, small lumps of living matter; *B*, cartilage-corpuscles transformed into basis-substance; *G*, cartilage-corpuscles, partly coarsely and partly finely granular. × 800.

The basis-substance is everywhere scanty, and partly hyaline, partly finely striated. Higher powers reveal a surprising variety in the sizes and shapes of these bodies. From the smallest lump (see Fig. 4, *L*) there are transitions to large oblong corpuscles, mostly arranged in groups and clusters. (See Fig. 4, *M.*) The shapes vary from small globules up to large protoplasmic masses, flattening one another, where they are arranged like twins or triplets. Similar formations can be seen in almost any portion of normal cartilage, and such groups have been looked upon by histologists of olden times as striking examples of cell-division. Now we are aware that twin formations are visible in the earliest as well as in the latest formations of this tissue, and mean merely a grouping from the very origin, but no division. That the,

comparatively speaking at least, active tissue should show lively division is beyond comprehension. Besides, how could the dense and tough basis-substance yield to make room for the rapid growth and division of cells? Since the fact is established that the basis-substance of hyaline cartilage is traversed by living matter, as well as the protoplasmic bodies themselves, the changes of the forms and sizes of the corpuscles are easily comprehended. Since the borders of the newly-formed cartilage exhibit small and finely granular corpuscles, we are justified in assuming that the corpuscles in this situation are at rest. The central portions, on the contrary, show coarsely granular bodies and clusters of medullary corpuscles, which seems to indicate that the latter part is breaking up into embryonal tissue in order to produce fibrous connective tissue, such as arises from a direct breaking up of bone-tissue. Intermixed with fully developed cartilage-corpuscles we meet those which show only a central nucleus or nucleolus, while the protoplasm is extremely pale, and differs from the surrounding basis-substance only by its slightly increased refraction. According to Spina, these forms mean a gradual change of cartilage-corpuscles into basis-substance, which view seems to be well founded.

Basis-substance originates in protoplasm, and may return to the protoplasmic state at any time. This tissue strongly supports the view of the changeableness of protoplasm, and as strongly contradicts the old-fashioned views of the stability of cells. A variety in the forms of cartilage-corpuscles, as we have just described, is seen in the transitional cartilaginous tissue known as "provisional callus" of shaft-bones.

6. *Bone-Tissue.* (See Fig. 5.)—After individual teeth have been lost, their sockets, after a while, disappear, and after all the teeth are gone the whole alveolar process fades away. This process, so common, is known by the term "absorption," but we are not satisfied with the idea conveyed by this expression, for it is evident that a hard tissue like bone cannot be disposed of with so little ceremony. It would seem more reasonable to expect that it must first be reduced to its protoplasmic condition, which as such is more readily disposed of. The results of our studies in this case fully justify us in assuming that such changes do take place. Both the cortical and the spongy portion are much reduced,—the former, in some places, to a complete disappearance, the latter by a diminution of the bulk of its trabeculæ. The way in which this is accomplished is twofold. Firstly, the bone-tissue is attacked upon its periphery, through the attachment of the periosteum, and secondly, by an enlargement and new formation of Haversian canals in a previously perfectly-formed mass of bone. The borders are corroded, jagged, and amply provided with bay-like excavations, such as we see so frequently in the process of inflammation of bone. The bays usually contain protoplasmic bodies of varying sizes and shapes, but we have nowhere met with multinuclear bodies or giant cells, which Kölliker termed in a rather humoristic way "bone-breakers" or "osteoklasts." The origin of these medullary corpuscles is occasionally traceable from previous bone-corpuscles that have been deprived of their surrounding basis-substance. (See Fig. 5, *E.*)

Since in one connection the basis-substance is, though infiltrated with lime-salts, just as viable as are the bone-corpuscles themselves, we can readily understand that after a dissolution or liquefaction of

the basis-substance protoplasmic bodies will reappear. The next stage is the elongation of the medullary corpuscles into spindles, and thence into fibrous basis-substance, with a simultaneous new formation of capillary blood-vessels.

The new formation of Haversian canals proceeds in exactly the same manner as in osteitis, although on a much smaller scale. First a bone-corpuscle, or several neighboring ones, become enlarged by

FIG. 5.

SENILE CHANGES OF BONE OF UPPER JAW.—*E*, border of bone-tissue jagged and showing bay-like excavations; *M*, bone-corpuscles broken up into medullary tissue; *H*, enlarged Haversian canal; *B*, bone-corpuscles transformed into basis-substance. × 800.

a liquefaction of the surrounding basis-substance. Next the living matter of such corpuscles increases in glistening homogeneous lumps. Some of the connecting canaliculi are widened into broad canals, the tenants of which increase in bulk. (See Fig. 5, *M*.)

Thus protoplasmic masses appear in a solid basis-substance, in which, by a hollowing of the living matter, new capillaries are produced, as one of us has described, in the process of osteitis, in 1872. An already-formed Haversian canal is widening by continual melting down

or dissolution of the adjacent basis-substance, with a gradual reappearance of embryonal or medullary corpuscles (Fig. 5, *H*), the ultimate destiny of which seems to be the production of fibrous connective tissue. This tissue at last is liquefied into protoplasm in a manner before described. In fact, the widened medullary spaces hold mainly such protoplasm, with but a few fat-globules.

An important question finds solution in the study of senile bone, viz : that of interstitial growth. Most modern histologists hold the opinion that bone-tissue grows by super-addition from without by apposition. A few writers, however, claim that bone may also grow by an increase of the basis-substance between the already-formed bone-corpuscles, which view seems to find support in the fact that the bone-corpuscles in old animals are farther apart than those in the young. Our studies enable us to account for this apparent interstitial growth as follows : It is a fact that with advancing age bone-corpuscles become fewer in number, the reason for which is that many of them are transformed into basis-substance, the same as Spina has claimed that cartilage-corpuscles are. Here and there we meet with a pale, finely granular bone-corpuscle without any vestige of a nucleus, and a refraction differing but slightly from that of the surrounding basis-substance. (See Fig. 5, *B*.)

Obviously a nucleated bone-corpuscle has changed into a finely granular protoplasmic body, which means an approach to glue, and subsequently to calcification. In looking over the tissue changes from the earliest embryonal life to the approaching physiological end of the individual, one must arrive at the conclusion that there is not for a moment absolute rest in the tissues ; temporarily, single protoplasmic bodies may make their appearance, such as we see in odontoblasts and ameloblasts. Temporarily, tissues may come into existence, such as cartilage, which soon afterward is lost, or, speaking correctly, becomes transformed into other tissues. So long as life lasts, protoplasm and the tissues sprung therefrom are unstable.

All tissues arise from protoplasm, or its medullary or indifferent corpuscles, and all tissues return to this embryonal or medullary state before they are absorbed.

Origin and decline show a striking similarity, and what is between the "threescore years and ten" is struggle and change of the whole person, as well as of all its constituent parts, the tissues.